Appendix C

Stabilization Treatment Process Decision Analysis Evaluation

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Introduction:

As described in EDF-1542, SSSTF Stabilization Treatment Process Selection, stabilization was selected as the treatment process for use at the SSSTF to treat waste to meet the ICDF landfill WAC. The discussion presented in this appendix describes the decision analysis evaluation conducted to evaluate the stabilization treatment processes available and describes the method for selecting the stabilization process that would best meet the designated requirements and evaluation criteria set forth in the evaluation. The evaluation was performed by personnel with a variety of backgrounds including project management, engineering, regulatory compliance, quality, and radiological and industrial safety.

In order to begin the decision analysis evaluation, the driving documents used for the project were listed and include:

Agency-Approved:
- OU 3-13 ROD
- OU 3-13 RD/RA Statement of Work
- Conceptual Design Report for the SSSTF (including Technical & Functional Requirements)

SSSTF Project Documents
- CERCLA Waste Inventory Database
- Waste Inventory Design Basis (EDF- 1540)

The stabilization treatment process mission for the SSSTF was extracted from the Technical & Functional Requirements in the Conceptual Design Report for the SSSTF and is defined as:

Treatment process or processes to treat the candidate CERCLA waste (soil, liquids, and debris) to meet the ICDF landfill WAC. (The amount of waste to be processed is 36,000 yd^3, 1,000 yd^3 of which is debris.)

Treatment of waste by stabilization has a distinct definition, as described by EPA-542-R-00-010, 9/2000:

Stabilization refers to processes that involve chemical reactions that reduce the leachability of a waste. Stabilization chemically immobilizes hazardous materials or reduces their solubility through a chemical reaction. The physical nature of the waste may or may not be changed by this process.

At Superfund sites, the regulatory definition of stabilization under the Resource Conservation and Recovery Act (RCRA) may be relevant to a project. Under the Land Disposal Restrictions (LDR) Program (40 CFR part 268), stabilization is the required treatment standard for certain types of waste. In addition, stabilization may be used to render a RCRA hazardous waste (defined under 40 CFR part 260) non-hazardous prior to disposal. RCRA defines stabilization (40 CFR 268.42) as "[a process that] involves the use of the following reagents (or waste reagents): (1) Portland cement; or (2) lime/pozzolans (e.g., fly ash and cement kiln dust) – this does not preclude the addition of *reagents (e.g., iron salts, silicates, and clays) designed to enhance the set/cure time and/or compressive strength, or to overall reduce the leachability of the metal or inorganic."*

Treatment of soils using stabilization may be implemented by a variety of systems and components. Stabilization treatment systems may range from simplistic to complex, from inexpensive to expensive, and from many specialized components to few multi-function components. This decision analysis evaluation was performed to examine the merits of various systems and select one the system for the SSSTF 30% design effort that best meets the requirements and criteria set in the evaluation.

For the purposes of the evaluation, soils were defined as earth material less than 5 in. and other debris like material less than 60 mm. The evaluation of the soil stabilization processes was applied to stabilizing all soil waste less than or equal to 5 in.

Decision Analysis Approach:

The decision analysis evaluation was performed on a generic system and component level and can be considered a qualitative evaluation. The analysis followed the format as specified in the DecisionPlus™ software that was used to conduct the evaluation/selection process.

Four design alternatives were evaluated to determine the best approach for stabilization. The recommended alternative was selected for use in the SSSTF 30% design package. The decision analysis evaluation was performed following the steps indicated:

1. Define the project mission (see discussion above)

2. Define the system functions

3. Develop the system requirements

4. Define the design alternatives

5. Follow the decision-making process through selecting an alternative

System Functions

In order to provide a nonbiased approach to evaluating the alternatives, the functions that the soil treatment process would be capable of performing as well as those functions that would not performed by the system are shown below.

1. Each system must be capable of performing the functions of:

    - Conveying Materials into the system
    - Adding reagents to waste
    - Mixing/blending waste with reagents
    - Confining Contaminants, and
    - Verifying the treated waste meets the waste acceptance requirements

2. Functions that each system would not have include:

    - treating low-volume anomalous waste

- treating TRU waste (> 100 nCi/g)
- treating non-contact handled waste (200 mR/hr contact) [Project Definition]
- treating organic constituents
- treating for radioactive constituents

System Requirements

To perform the decision analysis evaluation, all systems must meet the following minimum requirements in order to be considered for further evaluation and ranking.

1. Must be able to stabilize soil to meet LDR standards [T&FR]
2. Must be able to stabilize soil to meet the ICDF WAC (ICDF WAC is currently not developed) [T&FR]
3. Shall be able to process 35,000 yd^3 by 2010 (based on CWID horizons of 36,000 yd^3 waste – 1,000 yd^3 debris) [Project Decision]
4. Shall provide capability to perform reagent make-up [T&FR]
5. Shall provide for the ability to stabilize waste for nine months (March – November) and operate year round [T&FR]
6. SSSTF Treatment building shall be sized to contain stabilization process, truck unloading and loading, and special-case handling facilities
7. Soils stabilization process equipment shall be capable of decontamination
8. Soils stabilization process shall be able to mix the soil and reagents together to meet LDR/WAC levels.
9. Soils stabilization process shall be capable of receiving roll-on/roll-off (dependent on operation) scenario.
10. Soils stabilization process shall be capable of treating roll-on/roll-off (dependent on operation) scenario.
11. Stabilization process shall be designed to minimize loss of contamination to the environment and to protect human health
12. The soils stabilization process shall be conducted in a RCRA-compliant facility (substantive)
13. Soils stabilization process will be stabilization (regulatory definition)
14. Soils stabilization process shall be designed to allow sampling of treated soil
15. Stabilized waste must have a compression strength of at least 50 psi prior to disposal (criteria used for systems evaluation of alternatives)
16. Stabilized waste shall not have free liquids (paint filter test & visual)
17. Stabilization facility must be capable of receiving reagents into the stabilization process
18. Stabilization facility must be able to place stabilized waste into roll-on/roll-off containers
19. SSSTF soils stabilization facility shall control the generation of dust at or below 1 mg/m^3 (total dust) and silica level or concentrations below 100 $\mu g/m^3$ for specific silica minerals outside the stabilization process. (Assuming no PPE worn by personnel) [ACGIH; DOE Order 440.1A, Worker Protection]
20. SSSTF soils stabilization process shall be designed to minimize the spread of radionuclide in accordance with INEEL RadCon manual, PRD 183. (500 mrem total, both external & internal exposure)
21. Soils stabilization facility shall comply with Idaho dust emissions and NESHAPS requirements. [ID 58.01.01.650.651, and 40CFR.61.92]
22. Rate of waste soil to be stabilized will be 78 yd^3/day production based on the following calculation:

    - 36,000 yd^3 waste – 1,000 yd^3 debris = 35,000 yd^3 waste soil to be treated.
    - Assume 3-yr spread (level loading during 3 yr, receiving waste according to CWID)

- 2010 (end date for treatment) covered by Draft CWID (September 2000 version) as of 10-10-00
- 11,700 yd^3/yr
- 17 working days/month
- 150 days/yr.
- 6 productive hr/day [EDF-8 1547, Assumed INTEC]
- 78 yd^3/day production
- 13 yd^3/hr (waste) = 1 roll-off/hr
- Assume 75% waste loading; 16 yd^3 output [Typical commercial stabilization practice is 55-90; EDF-3 1542]

Evaluation Criteria

Evaluation criteria were developed for evaluating the stabilization alternatives. Six primary criteria were determined with subcriteria defining intent of each primary criterion. The criteria with each of the subcriteria are listed below.

1. Quality Control:
   - Mixing Effectiveness
   - Ease of Post-Treatment Sampling
   - Process Consistency

2. Operations
   - Maintainability/Spare Parts
   - Controllability
   - Operability
   - Reliability
   - Able to Decontaminate to Support Operations
   - Able to Receive Reagents
   - Ease of Filling Stabilized Waste Staging Container

3. Cost (ROM cost estimates are included in Attachment #2 to this appendix)
   - Capital
   - Operational
   - D&D
   - Maintenance
   - No. Personnel Required

4. Implementability
   - Complexity of Design
   - Complexity of Operation
   - Proven Track Record for Systems
   - Schedule:
     - Construction
     - Operations
     - D&D
   - Able to Meet Closure in LCAM

5. Inherent Safety (Safety features inherent in the equipment and/or design, requiring less operational intervention to remain safe)
   - Worker Internal Exposure
   - Control of Dust
   - Confinement
   - Reliance on Facility for Confinement
   - Control Direct Exposure to Radiation

6. Flexibility
   - Robustness (Able to Handle Non-Routine Process Envelope)
   - Allow Failed Treated Waste Reprocessing
   - Able to Recover from an Abnormal Event

Following criteria identification, a pair-wise comparison was performed for each of the primary criteria to assign each a weighting value. The Decision Criteria Plus software was used to facilitate the comparison. The six primary criteria were, in the order of ranking from highest to lowest: Quality Control, Operations, Cost, Implementability, Inherent Safety, and Flexibility. Table C-1 shows the ranking of each of the main criteria and the associated weighting.

Table C-1. Pair-wise Comparison Ranking

Rank	Criteria	Weighting Percent
1	Quality Control	38%
2	Operations	23%
3	Cost	18%
4	Implementability	9%
5	Inherent Safety	8%
6	Flexibility	4%
		100%

Alternative Descriptions

Four systems have been considered for evaluation which meet the requirements and minimum criteria. The decision analysis evaluation of these systems highlights issues relevant to the implementation of the SSSTF stabilization process capability. For the purposes of the evaluation, the assumption was made that all four alternatives will have some type of primary dust suppression enclosure, which will be an environmental enclosure only. These systems are described as System Alternatives 1, 2, 3 and 4 below. For each alternative, the design intent in order to meet confinement criteria is to provide a facility interface at the area of transport unloading. This interface will provide control of ventilation air and confinement pressure.

System Alternative 1: Pug Mill System

The pug mill system is a continuous multi-functional system comprising multiple components with each component functionally specialized. Components include:

- In-Feed Roll-On/Roll-Off – Although the soil is assumed to not contain any material greater than 5 in., it will still be screened prior to being discharged into the mixing system.
- Screen –The waste from the roll-off would be discharged onto a screen. Large material not passing through the screen would be directed into another container to be treated as debris. The screen may need to vibrate to segregate material.
- Bin – The material that passed through the screen would then be discharged into the staging bin prior to mixing. Soil will be continuously discharged from the staging bin into the pug mill.
- Mixing Unit – The pug mill is a continuous feed system that will receive waste and reagents at specified rates and mixed using paddles that rotate inside the pug mill.
- Discharge Unit – The pug mill will discharge into the roll-on / roll-off container on the waiting truck. When the truck is full the treated soil discharging from the pug mill will be sent to a surge bin until a new truck and roll-on/roll-off container can be moved in to collect the treated soil.
- Container Interface
- Output Interface

A schematic of the pug mill system is provided in Attachment 1, Alternative 1 - Pug Mill System.

System Alternative 2: Cement/concrete Mixer

The cement/concrete mixer system is similar to the pug mill except that it is a batch system with no interior moving parts. The paddles are affixed to the interior of the mixer and the entire mixer rotates. The components of the cement/concrete mixer system include:

- In-Feed Roll-On/Roll-Off – Although the soil is assumed to not contain any material greater than 5 in., it will still be screened prior to being discharged into the mixing system.
- Screen –The waste from the roll-off would be discharged onto a screen. Large material not passing through the screen would be directed into another container to be treated as debris. The screen may need to vibrate to segregate material.
- The design base case waste loading is 75% which will result in outputs of 47,687 yd^3 to the ICDF. onto a screen. Large material not passing through the screen would be directed into another container to be treated as debris. The screen may need to vibrate to segregate material.
- Bin – The material that passes through the screen would then be split into two or more bins and treated as separate batches
- Gate – Gates will be located on each bin to discharge the batch into the mixer with the reagents. Multiple batches will be required for each roll-on/roll-off transport.
- Rotary Cement/concrete Mixer – This type of mixer has paddles that are fixed to the interior of the mixing drum. The drum is rotated using gears on the outside that are easily maintainable. There are no moving parts inside the drum.
- Out-Feed – After a batch has been sufficiently mixed the drum will be rotated and the treated soil will be dumped into a waiting roll-on/roll-off container.

A schematic of the cement/concrete mixer system is provided in Attachment 1, Alternative 2 – Concrete Mixer.

System Alternative 3: Komar Shredder-Mixer

The Komar Shredder-Mixer is a multi-functional system with custom-built equipment capable of performing size reduction, material conveyance, and mixing/blending within one basic unit (e.g. an auger type shredder/blender type system).

- In-Feed Roll-On/Roll-Off – The soil is assumed to not contain any material greater than 5 in., it will directly discharged into a split staging bin.
- Bin – The soil will be split into two or more bins and treated as separate batches
- Gate – Gates will be located on each bin to discharge each batch into the process hopper with the reagents.
- Process Hopper – The process hopper receives the soil and reagents and is located on top of the mixer-shredder.
- Komar Mixer-Shredder – This type of mixer is a very powerful dual auger system that will mix and shred most materials.
- Out-Feed – As the soil and reagents are mixed and shredded, the treated soil will be directly discharged into a waiting roll-on/roll-off container.

A schematic of the Komar shredder-mixer is provided in Attachment 1, Alternative 3 – Komar Shredder-Mixer.

System Alternative 4: Mixing Basin

The mixing basin system is a custom designed facility structure combined with commercial material handling equipment for segregation, mixing and loading. This will be accomplished in the basin with the articulated arm equipped with certain end effectors consisting of a backhoe bucket, a loading bucket, hydraulic jaws or others as may be required.

- In-Feed Roll-On/Roll-Off – The soil is assumed to not contain any material greater than 5 in., it will directly discharged into the mixing basin.
- Steel-Lined Basin – The mixing basin will be large enough to accommodate approximately 26 yd^3 of waste and will be lined with steel plating.
- Reagent Additives – The proper volume of reagents will be added in the mixing basin via conveyors or chutes or pipes.
- Mister – A mister will be used to keep dust levels at acceptable levels during the mixing operation by keeping the soil moist.
- Backhoe (Hydraulic Articulated Arm) – A skilled operator will conduct the mixing of the soil and reagents using a hydraulic articulated arm.
- Interface on Outlet – After the soil has been treated it will be loaded directly into empty roll-on/roll-off containers using the hydraulic articulated arm.

A schematic of the mixing basin is provided in Attachment 1, Alternative 4 – Mixing Basin.

Comparison of Alternatives

Each of the alternatives was rated numerically for the subcriteria listed in the Evaluation Criteria Section. The criteria were weighted using a scale of 1 to 10, (with 1 being least important and 10 being the most important) based upon collective discussion and subsequent consensus. Criteria weightings for this evaluation are included in Table C-2. The comments reflect the intention regarding the category and the specific ranking assigned.

Score Results and Considerations:

Following the input of the decision analysis data into the DecisionPlus™ software program, Alternative #4, mixing basins, received the highest score and is the recommendation for implementation of the stabilization process in the 30% design. The scoring results with highlighted basis considerations are shown the decision analysis diagram in Figure C-1 and were based on group discussion with concensus conclusions. Figure C-2 illustrates the relative ranking of the four different alternatives with the Mixing Basins scoring only slightly higher than the Cement/concrete Mixer followed by the Komar Shredder-Mixer and the Pug Mill. Prior to commencing 90% design it is suggested that confirmation of possible mitigating issues be investigated to assure or confirm the results of this evaluation. There are some factors that clearly require additional research before the alternative selected moves into final design stages. Those factors or mitigating issues should include thorough review of operational radiological hazards for the wastes planned for treatment, formal cost estimate comparisons between the alternatives, detailed investigation into throughput capabilities for each alternative, and a review of operational limitations for each alternative. If it is apparent that the confirmatory investigations contradict the results of this evaluation, a new evaluation should be held.

Table C-2. Decision analysis scoring.

Evaluation Criteria	Pug Mill System	Cement/concrete Mixer	Komar Shredder-Mixer	Mixing Basin	Comments
TOTAL COST **Rating**	$1.43M **7**	$1.26M **7**	$2.01M **5**	$0.84M **9**	Building included. Not included: operators, HVAC, reagents
Capital	$1.21M	$0.96M	$1.73M	$0.72M	
Operational	$0.11M	$0.15M	$0.14M	$0.06M	Supplies & Maintenance (3 years)
D&D	$0.11M	$0.15M	$0.14M	$0.06M	
No. of personnel required	2 operators 1 Radcon Tech	2 operators 1 Radcon Tech	2 operators 1 Radcon Tech	2 operators 1 Radcon Tech	
INHERENT SAFETY					
Worker Exposure & Dust Control **Rating**	2 transfers, dust generation, some exposure **6**	3 transfers, dust generation, highest exposure **5**	3 transfers, dust generation, highest exposure **5**	2 transfers, with dust generation controlled with de-misting, slight exposure **8**	Internal exposure for inhalation from dumping, equipment transfer, adding reagents
Confinement **Rating**	Less confined but a continuous feed and discharge system **7**	Less confined but rates higher because it is a batch system **8**	Most confined batch system **9**	Open to environment, least confined **5**	Assume inherent confinement of system can be controlled
Reliance on facility for confinement **Rating**	High wind, many transfers would shut it down **6**	Open discharge with many transfers **5**	Completely enclosed batch system with enclosed discharge **8**	Fewer transfers than pug mill but slightly more exposure **7**	If move facility, how would that affect operation
Industrial Safety without controls	All moving parts, paddles, etc. are internal and would require more entries for repair	All moving parts are external, however some access to interior may be required.	Maintenance is the most complex & dangerous. Entry is horizontal.	Easiest to access and maintain.	Assuming equal maintenance schedules, how safe/unsafe is operation? Fewer people equals more safe; more

Evaluation Criteria	Pug Mill System	Cement/concrete Mixer	Komar Shredder-Mixer	Mixing Basin	Comments
					confined equals more hazard
Rating	3	5	2	8	
Control direct exposure to gamma rad	Fairly complex with buildup, and more maintenance time	Slightly complex with buildup, and slightly more maintenance time	Complex, high buildup, most maintenance time	Simple design, low buildup, no exposure to operator, own shielding	ALARA, exposure during maintenance (operations exposure are equal)
Rating	3	4	2	7	
FLEXIBILITY					
Robustness (able to handle non-routine)	Paddles susceptible to jamming/internal damage & fines	Handle wide variety of inputs (5-in, okay; fines susceptibility	Versatile, but cannot handle large metal objects	Can remove/ accommodate abnormal debris	Ability to handle non-routine materials entering process.
Rating	3	6	8	9	
Allow failed treated waste reprocessing	Susceptible to "balling up"	Susceptible to "balling up"	Not susceptible to buildup of moist material, high energy systems	Operator controlled and can be manipulated.	Assume material is not solid – looks like soil
Rating	5	4	9	8	
Able to recover from abnormal event	Difficult to extract from with loss of power/equipment failure; difficult confined entry	Could be manually dumped; confined entry	Difficult to extract from with loss of power/equipment failure; difficult confined entry	Not confined, easy access, could recover with mobile equipment	
Rating	2	4	2	9	
OPERATIONS					
Maintainability/spare parts	**4** Crane required for paddle removal & maintenance	**8** Low maintenance, not many parts, hydraulic dumping likely	**4** Spare parts expensive, crane required for auger maintenance cutting edges/hard surfaces	**7** Spare parts expensive, hydraulic parts, cutting edges	
Rating	4	8	4	7	
Controllable	Automated, but mixing is continuous rather than batch, therefore	Automated batch mixing	Automated with intense mixing	Operator controlled rather than automated will reduce repeatability	Define as: degree of automation; repeatability; feedback, and consistency

Evaluation Criteria	Pug Mill System	Cement/concrete Mixer	Komar Shredder-Mixer	Mixing Basin	Comments
Rating	consistency may vary. 7	8	9	and consistency 5	of operations
Operability **Rating**	Remote panels/auto output surge bin 7	Remote panel/ auto minimal operation effort **8**	Remote panel/ auto minimal operation effort **8**	Manual - more operator effort **6**	Skill level operator effort
Reliability **Rating**	Most prone to downtime due to equipment damage/plugging, most delicate **5**	Few moving parts, proven system. **9**	Most complex components, sophisticated controls, proven system. **8**	Least complex but proven system. **6**	
Decon to support operations **Rating**	Confined spaces possible disassembly needed, potential dry putter decon **3**	Confined space, less difficult to decon, potential dry putter decon **6**	Confined space, possible disassembly, potential dry putter decon **3**	Most accessible, largest surface area, confined space **8**	
Able to receive reagents **Rating**	Same as decon	Same as decon	Same as decon	Same as decon	
Ease of filling treated waste staging container **Rating**	Horizontal output continuous, need surge bin 7	Batch dump direct to 13 yd^3 container **8**	Batch vertical dump **8**	Batch manual unload; time dependent; skill of the craft **4**	
IMPLEMENTABLE					
Complexity of Design **Rating**	Screen/debris bin need hopper & continuous feeder (vibratory) 7	Screen/debris bin split input load to 6-8 yd^3 7	Height, split input load to 6-8 yd^3 , ramp above/below **6**	Output interface, No screen, No load splitting **9**	System design
Complexity of operation	PLL Most components, automation testing internal locks, V&V, alarms	PLL automation/ interlocks, V&V, alarms	PLL automation/ interlocks, V&V, alarms	Least parts	Startup procedures, training, testing

Evaluation Criteria	Pug Mill System	Cement/concrete Mixer	Komar Shredder-Mixer	Mixing Basin	Comments
Rating	6	6	6	9	
Proven track record for systems **Rating**	See Comment 9	See Comment 9	See Comment 9	See Comment 9	All 4 alternatives have proven track record
Schedule: Construction, Operations, D&D **Rating**	Long lead items: 9-12 months 7	Long lead items: 6-9 months 9	Long lead items, 9-12 months, ramps 7	9-months lead on hoe 9	Salvage value?
Able to meet closure in LCAM **Rating**	Can break apart to put in landfill 7	Cut to put in landfill 7	Difficult to put in landfill, but very low secondary waste. 5	Easy to close 9	Ease of transfer to landfill; Clean closure 25-30 year away
QUALITY CONTROL					
Mixing Effectiveness **Rating**	See Comment 9	See Comment 9	See Comment 9	See Comment 9	All processes mixing equal to achieve TCLP
Ease of post-treatment sampling **Rating**	See Comment 9	See Comment 9	See Comment 9	See Comment 9	Low weight factor sampling, equal for all
Process Consistency **Rating**	Automated, continuous system, inherent problem with consistency 6	Automated batch system 9	Automated batch system 9	Dependent on skill of the craft 7	How consistent is the product?
MISCELLANEOUS NON-RANKED CRITERIA					
Through-put	10 yd^3/hr	13 yd^3/hr	13 yd^3/hr	21 yd^3/hr	30 yd^3/hr at Envirosafe
Hours for 78 yd^3	8 hr	6 hr	6 hr	4 hr	

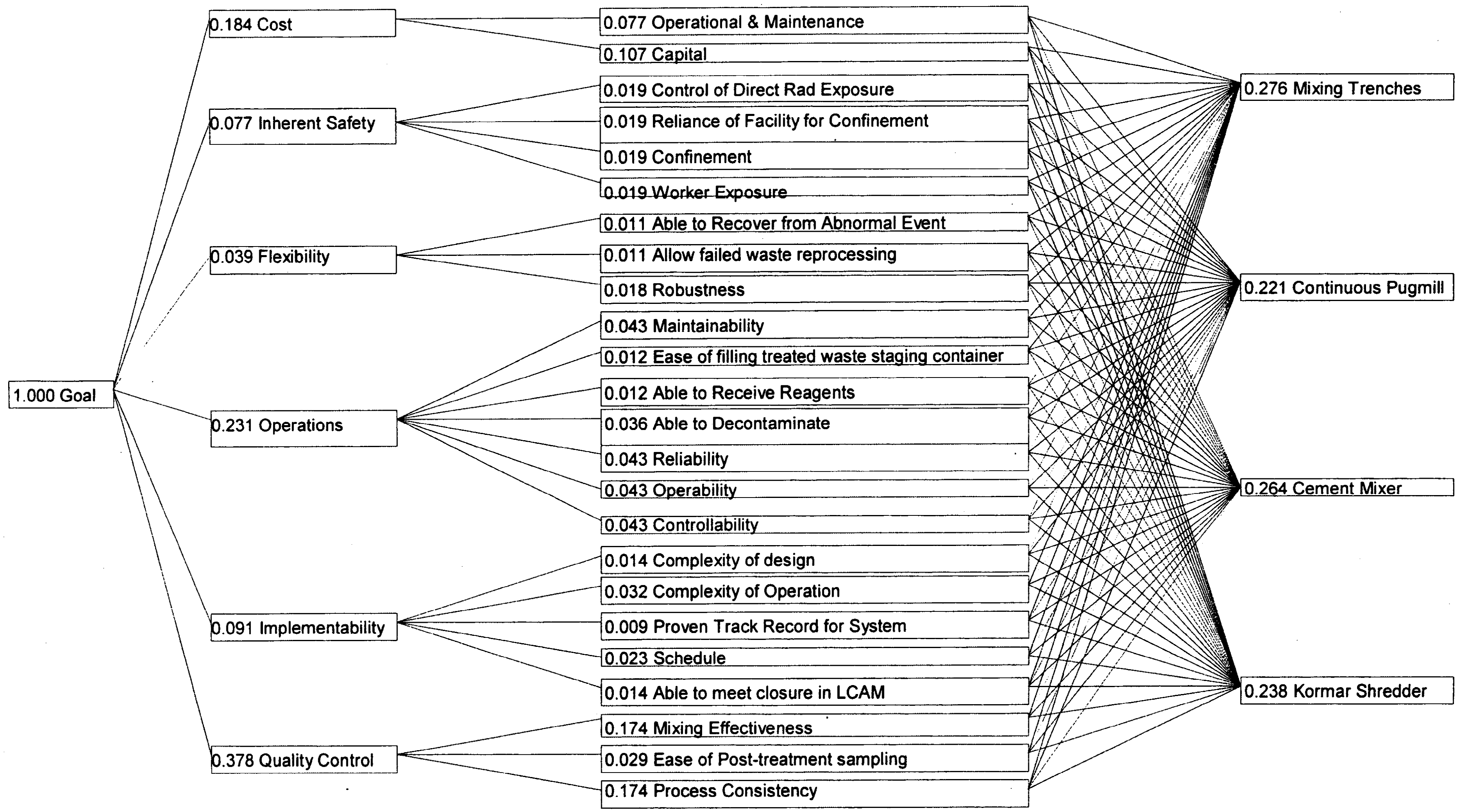

Figure C-1. Decision analysis diagram.

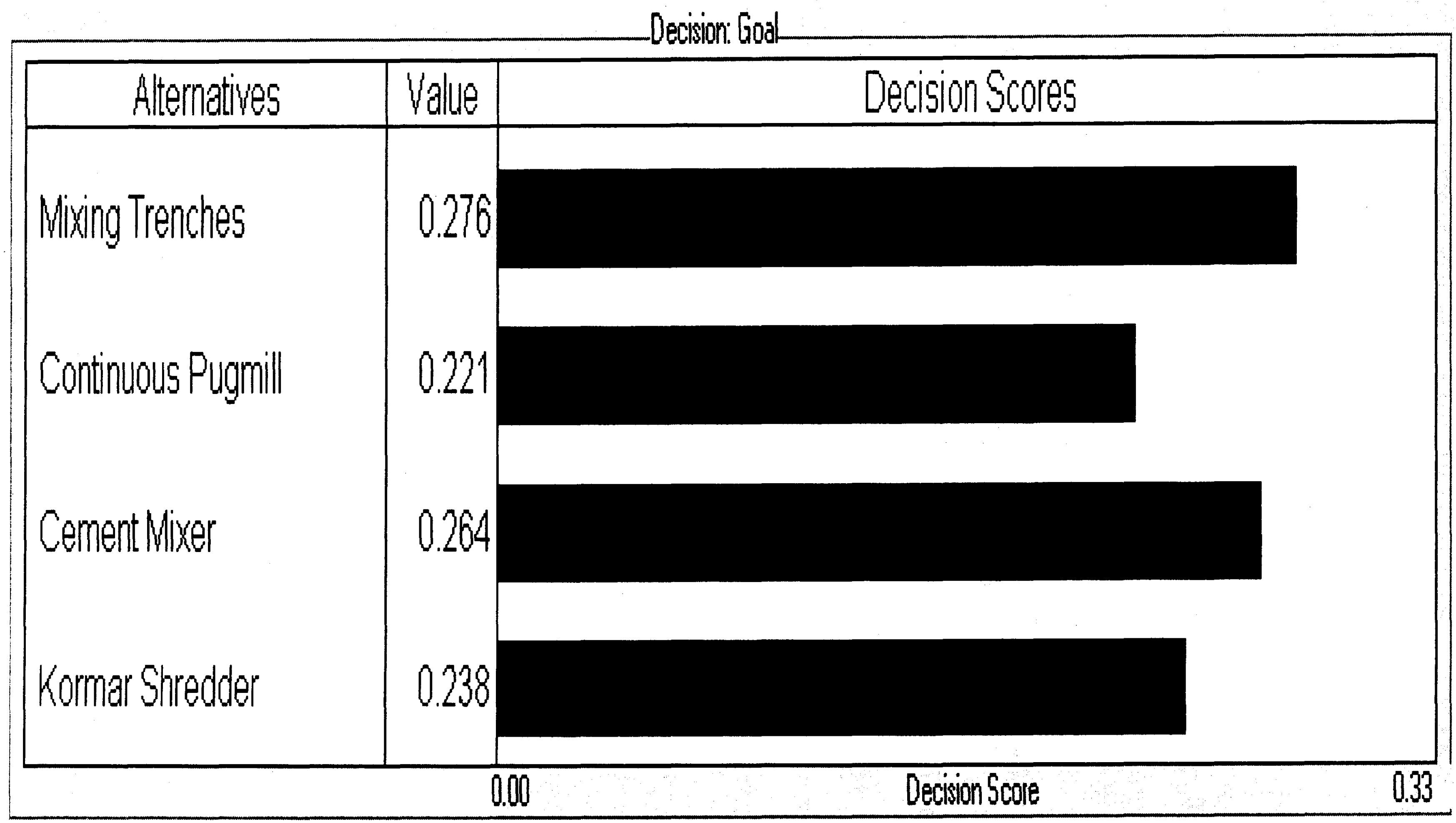

Figure C-2. Decision analysis results.